EXPOSURE TO PERSISTENT ORGANOCHLORINES AMONG ALASKA NATIVE WOMEN

Carol H. Rubin[1], Anne Lanier[2], Marie Socha[1], John W. Brock[1], Stephanie Kieszak[1] and Shelia Zahm[3]

ABSTRACT

Objectives: To report the levels of DDT, DDE, other chlorinated pesticides, and PCBs found in 131 Alaska Native women who had serum samples collected between 1980 and 1987 and to compare these levels to other published studies of DDE and PCB exposure among U.S. women.

Study Design: Review of data collected during a case-control study of the relationship between organochlorine chemicals and breast cancer. Data for case and control women were pooled in this analysis because case-control differences were found to be minimal and because serum samples pre-dated cancer diagnoses by 3 to 10 years.

Results: More than 99% of the women had detectable levels of p,p-DDE (mean 9.10 ng/mL or ppb). Mean total PCB level was 7.56 ppb. Levels of exposure varied by geographical location and ethnic identification, which may be a reflection of dietary differences. Five of the organochlorines were detected in at least half of the study population. Results were recalculated using detection limits corresponding to other published studies of DDE and PCB levels in U.S. women. Alaska women had levels similar to those reported from New York women collected in the 1980s. We compared the PCB congener levels measured in Alaska Native women with levels reported in Arctic animals and found similar PCB congener profiles. The six most frequently detected contaminants in Alaska Natives were also detected in the marine mammal samples reported by Becker et al (5).

Conclusions: Our study identified widespread Alaska Native exposure to organochlorines that originated outside of the Arctic, a finding also seen in other studies. Our results provide a reference baseline for exposure levels during the 1980s, but further research is necessary to assess temporal trends in exposure among Alaska Natives. Further, the need for national and international inter-laboratory standardization for testing for persistent organochlorines to facilitate comparisons between Alaska Natives and other American populations is clearly demonstrated. *(Int J Circumpolar Health 2001;60: 157-169)*

Key words: *organochlorines, Alaska Natives, subsistence diet, DDE, PCBs, Arctic pollutants*

[1] National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, GA

[2] Alaska Native Health Board, Anchorage, AK

[3] National Cancer Institute, National Institutes of Health, Rockville, MD

Material may be protected by copyright law (Title 17, U.S. Code)

Man-made chemicals that originate outside the arctic are found in Alaska. These chemicals volatilize in warmer climates, drift in the atmosphere, precipitate out upon reaching colder climates and are deposited in cold northern regions (*1-3*). The most frequently identified chemicals are classified as organochlorines, persistent organic pollutants (POPs), or polyhalogenated diaromatic hydrocarbons (PHDHs). Examples of these chemicals include 2,2-bis(*p*-chlorophenyl)-1,1,1-trichloroethane (p,p-DDT) and its breakdown product, 1,1-dichloro-2,2-bis (*p*-chlorophenyl)-ethylene (p,p-DDE), as well as other pesticides and the many congeners of polychlorinated biphenyls (PCBs). Although most of these chemicals have been banned in the United States since the early 1970s, they are still manufactured and used internationally (*4*).

It is presumed that Alaska Natives are exposed to these environmental contaminants because their subsistence diet includes marine mammals with documented high tissue levels of these chemicals. Longitudinal sampling of whales, seals, and walrus points to the bioaccumulation and biomagnification of POPs within the subsistence food chain in Alaska (*2,5*). The purpose of this paper is to present results from the first analysis of organochlorines in serum collected from Alaska Natives and to compare these to levels found in women in the continental U.S. and to PCB congener profiles found in Arctic marine mammals.

Origin of Arctic Pollutants

Quantifiable levels of organochlorine chemicals exist in the Alaska environment. Some accumulation of these man-made chemicals can be attributed to local pesticide application or to Alaska-based occupational use of organic chemicals. DDT was used as early as 1948 for the control of mosquitoes and black flies in the Yukon (*6*), and other organochlorinated pesticides may also have been used at military bases in Alaska (*5*). PCB exposure may have resulted from PCBs released from industrial sources (e.g., power stations and mines) and from the use of PCB-laden oil for dust control on dirt roads (*6*). Although PCB use in manufactured electrical products was discontinued in 1977 in the United States (*7,8*), this compound is still found in products produced prior to the ban (*1*).

Most of the chemical pollutants in Alaska's environment, however, appear to originate in areas far from the Arctic. The process by which these contaminants are transported to and deposited in Alaska is called atmospheric or geographic drift (*3,9*). This process involves the volatilization of chemicals

Material may be protected by copyright law (Title 17, U.S. Code)

used in warmer climates, movement of these chemicals via air or water currents, and the deposition of these chemicals in colder climates. Pollutants arrive in Alaska via atmospheric and oceanic transport from industrialized and developing regions (*6,10*). When they reach cooler northern regions, these chemicals are likely to precipitate out of the atmosphere and contaminate water and land areas or bioaccumulate in marine species (*6,11*).

The accumulation of organochlorine chemicals in marine mammals was recorded as early as 1970 when DDT was found in the blubber of Baltic ringed seals sampled from Arctic regions (*12*). By 1980, PCBs had been detected in many Arctic animals (*6, 13-18*). PCBs are lipophilic chemicals that bioaccumulate in the fat stores of animals and humans. Body burdens increase with age because elimination of these chemicals is slow. For most of these chemicals, excretion occurs primarily via lactation, with minimal loss through fecal and urine output (*7*).

The subsistence diet for Alaska Natives (i.e., Eskimos, Indians, and Aleuts who originally occupied the geographical regions now known as Alaska) includes marine mammals in which persistent organic pollutants may bioaccumulate (*19*). Although environmental and animal levels of contamination are declining in industrialized temperate countries, temporal trends of contaminant levels in circumpolar countries are inconsistent and in need of study (*4, 6, 10, 20-24*).

METHODS

The Centers for Disease Control and Prevention (CDC), the National Cancer Institute (NCI), and the Indian Health Service (IHS) collaborated with the Alaska Area Native Health Service (AANHS) to conduct an age-group-matched case-control study of the relationship between exposure to organochlorine chemicals and breast cancer among Alaska Native women. The study included analysis of 131 stored serum samples collected during an Alaska-wide serosurvey for Hepatitis B conducted in the mid-1980s. Excess serum from that survey was frozen and is held at optimal conditions as part of the CDC's Arctic Investigations Program. Sixty-six case women were identified from the Alaska Area Native Health Center Cancer Registry and 1 ml samples of their stored serum were withdrawn from the serum bank; 66 control women were identified whom also had samples stored at the serum bank. Women were selected as controls if they had a stored

Material may be protected by copyright law (Title 17, U.S. Code)

serum sample that was drawn the same year as the samples from case women, were within 5 years of the age of the matched case, and were alive and cancer-free at the time of the case woman's cancer diagnosis. No information was available concerning diet or lactation history. All personal identifiers were removed prior to laboratory analysis. At the time that serum was drawn, the mean age of the 131 women who had sufficient serum for laboratory analysis was 57 years. In this manuscript, we pooled data for case and control women because case-control differences were found to be minimal and because serum collection pre-dated cancer diagnoses by 3 to 10 years (unpublished data).

Our study population (n=131) was grouped into 3 ethnic categories in order to maintain the anonymity of individuals enrolled into the study. Eighty-three (63.4%) of the women were Eskimo, 22 (16.8%) were Aleut, and 26 (19.8%) were American Indian. Of the 131 study subjects, 125 were born in one of the four geographical regions of Alaska (i.e., south central Alaska (Anchorage service area), northwestern Alaska (Barrow, Kotzebue and Norton Sound combined service areas), southwestern Alaska (Yukon Kuskokwim and Bristol Bay combined service areas) and interior Alaska (Interior Alaska service area) (Figure 1). Of the six women not born in Alaska, one was born in the lower 48 states and 5 could not be determined (Table 1). For the 125 women born in Alaska, there was a strong correlation (r=0.84) between geographic location at birth and geographic location at time of serum draw ($p < .0001$). Most Eskimo women originated from northwestern and southwestern Alaska. The majority of Indian and Aleut women were born in south central Alaska.

Laboratory Methods

The serum samples were analyzed at the laboratories of CDC's National Center for Environmental Health (NCEH) in Atlanta. We measured DDT and its metabolite DDE, 13 other persistent pesticides, and polychlorinated biphenyls (PCBs) according to previously published methods (*26*). A reagent blank and a quality control sample were added to each batch of 10 submitted samples. Each sample was extracted by solid-phase extraction and then analyzed on two separate gas chromatographs with electron capture detection. The two chromatographs used two different columns (DB5 and DB1701) in order to reduce detection interferences and improve selectivity.

Serum samples were also analyzed for cholesterol and

Material may be protected by copyright law (Title 17, U.S. Code)

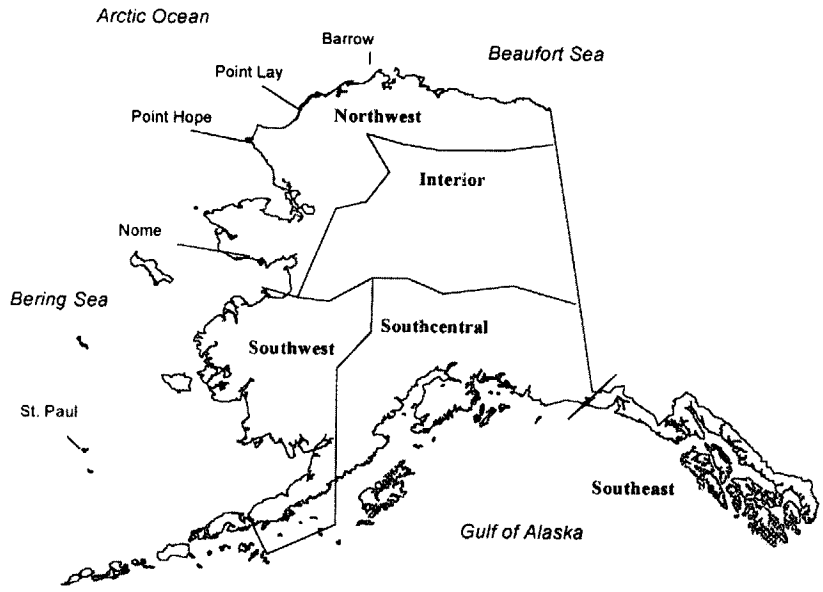

Fig. 1. Map of Alaska delineating geographic quadrants where Alaska Natives resided at time of serum collection, and sites where animal data were collected.

Table 1. Ethnicity and region (1 woman from lower 48 states, 5 unknown) at birth for the 125 women with stored serum samples collected in the mid-1980s, and available information regarding place of birth (divided into four geographic areas in Alaska).

Geographical Region	Geographical Region Eskimo	Eskimo Aleut	Aleut Indian	Indian Totals
Southcentral	2	16	16	34
Northwestern	32	0	0	32
Southwestern	43	6	4	53
Interior	1	0	5	6
Totals	78	22	25	125
Percent	62.4	17.6	20.0	100

triglycerides on a Kodak Ektachem 250 Dry Chemistry Analyzer (Ortho Clinical Diagnostics, Rochester, NY), and total lipids were calculated according to a standard formula (27). A lipid-adjusted total PCB variable was created by summing all congener values and dividing by total lipids. The intraset coefficient of variation (CV) was 8.5% for PCBs and 18.0% for DDT and the interset CV was 13% for each variable.

Material may be protected by copyright law (Title 17, U.S. Code)

Methods Used to Select Referent Studies

We used several different approaches to gain perspective on the interpretation of our analytic results. We restricted our comparison to published manuscripts that described studies in which samples were collected around the same time, from women of the same age (± 10 years), and analyzed and statistically corrected in the same manner as were the samples collected from Alaska Native women in our study. First, we compared our results with those from another study that used the same analytical laboratory that we did and therefore employed the same analytical method. Second, we compared our results with those from previously published studies that used varying laboratory techniques, including different analytical methods, lipid adjustment factors, recovery correction reports, and limits of detection (LOD). To increase comparability with data from these studies, we statistically reassessed our results by applying the higher detection limits originally used in several earlier studies (*28, 29*). For this re-assessment, we set the detection limit for total PCBs at 2.0 ppb. PCB congeners were summed, and if the sum met or exceeded the detection limit of 2.0 ppb, we listed the actual value obtained. If the value of the summed congeners did not equal or exceed 2.0 ppb, then the individual value was labeled as below detection limit and its value was treated as a zero. The detection limit for p,p-DDE was set at 1.0 ppb which is the limit used in the earliest reports (*28, 29*).

In generating comparison values from published case-control studies, we calculated an overall arithmetic mean. We also contrasted our results with published organochlorine levels in marine mammals. No animal samples were collected for our study. The presence of various organochlorines and PCB congener profiles found in Alaska Native women in our study were compared to reports from animal studies. We used animal data collected by the Alaska Marine Mammal Tissue Archival Project during the 1980s (*2*). We averaged seal and whale levels from samples reported from northwestern Alaska (Barrow, Nome, Point Hope, and Point Lay) and from southwestern Alaska (St. Paul Island) (Figure 1). For our comparison, we calculated a species-specific mean for two geographic locations. All PCB congener values above the detection limit were summed and labeled as total PCBs.

Material may be protected by copyright law (Title 17, U.S. Code)

RESULTS

Five of the 15 organochlorine analytes were detected in 50% or more of our study population. Table II shows the percentage of women in whom these analytes were detected and the specific recovery-corrected mean values; means were calculated using the actual values obtained in all 131 subjects. We present both crude and lipid-adjusted levels in order to facilitate comparison with other published data. The analyte p,p-DDE was found in 99.2% of the subjects at a mean value of 9.10 ng/mL (lipid-adjusted mean 1395.74 ng/g lipid). Mean total PCB was 7.56 ppb (lipid-adjusted mean 1153.07 ng/g lipid); mean values for the PCB congeners ranged from 0.18 ng/mL for congener 156 to 2.39 ng/mL for congener 153. (Table II)

Table II. Rank order listing of the 5 analytes found in at least 50% of the study population of 131 Alaska Native women. All values are recovery corrected. Crude means (in ng/mL serum), lipid-corrected means (in ng/g lipid), 95th percentiles, and standard deviations are presented.

	Limit of Detection	Percent detectable	Mean* (sd) Crude Values (ng/mL serum)	95th percentile Crude Values (ng/ml serum)	Mean* (sd) Lipid-corrected (ng/g lipid)	95th percentile Lipid-corrected (ng/g lipid)
p,p-DDE	0.41	99.2	9.10 (4.73)	18.07	1395.74 (760.47)	2815.98
Hexachlorobenzene	0.05	98.5	2.58 (1.88)	6.05	389.52 (296.95)	953.21
Trans-nonachlor	0.19	70.2	0.96 (1.08)	3.02	149.89 (166.00)	515.94
Oxychlordane	0.13	59.5	0.56 (0.69)	2.04	85.97 (108.59)	322.27
Dieldrin	0.15	52.7	0.26 (0.30)	0.88	38.31 (42.80)	124.25
PCB Congeners:						
153	0.22	93.9	2.39 (2.11)	7.04	367.19 (333.48)	1118.71
138	0.16	84.7	1.15 (0.93)	3.10	174.67 (146.38)	464.13
118	0.16	74.0	0.84 (0.78)	2.20	127.02 (121.24)	373.40
180	0.15	68.7	0.64 (0.66)	1.86	98.23 (103.49)	298.87
74	0.13	59.5	0.25 (0.26)	0.76	37.33 (40.69)	110.42
187	0.13	53.4	0.26 (0.33)	0.94	39.87 (52.61)	166.77
156	0.15	50.4	0.18 (0.20)	0.61	27.61 (31.98)	86.51

* Analyte means are for those chemicals that had greater than 50% detection of the analyte. However, the means include all 131 values in the calculation of the mean.

When we reassessed our results by applying the higher detection limits originally used in some of the reference literature, Alaska Native women had an overall arithmetic mean p,p-DDE level of 9.09 ng/mL (sd 4.74). The overall mean total

Material may be protected by copyright law (Title 17, U.S. Code)

PCB level was 7.20 ng/mL (sd 5.97). Table III displays these results in comparison to other studies that used these elevated levels of detection when measuring levels in similar-aged women. In the study of women from Missouri, Dorgan used the same laboratory that we did and also reported lipid-corrected results (30). These comparison data came from 200 women who had serum samples collected between 1977 and 1987 and stored in the Columbia Missouri Cancer Serum Bank. The mean p,p-DDE level in this population was 21.09 ng/mL (sd 17.80), and the mean total PCB level was 3.20 ng/mL (sd 2.50) (Table III). The other 2 studies in Table 3 did not identify which PCB congeners were used to calculate total PCBs; our study and the Dorgan study used the 28 PCB congeners footnoted in Table III.

Table III. Comparison of p,p-DDE and total PCB values in women from four different studies and from the general population (NHANES II). All values have been calculated or recalculated using a 1.0 ng/mL (ppb) limit of detection for p,p-DDE and 2.0 ng/mL (ppb) for total PCBs. Mean values represent combined case and control data.

Study	Overall arithmatic mean p,p-DDE (sd), (ng/mL)	Overall arithmatic mean total PCBs, (sd) (ng/mL)	N	Year of Sample	Study area
Rubin et al	9.09 (4.74)[a]	7.20 (5.97)[a]	131	1980 - 1987	Alaska
Dorgan et al	21.09 (17.80)[a]	3.20 (2.50)[a]	200	1977 - 1987	Missouri
Krieger et al	43.2 (17.55)	4.60 (1.54)	300	1964 - 71	California
Wolff et al	8.54 (7.44)	7.03 (3.24)	229	1985 - 91	New York

[a] represents recovery corrected data from this study
The reference studies did not cite which PCB congeners were used to calculate total PCBs, nor did they specify recovery correction status. For Rubin et al and Dorgan et al data, total PCBs were calculated as the sum of the PCB congeners 28, 52, 56, 66, 74, 101, 105, 110, 118, 138, 146, 153, 156, 170, 172, 177, 178, 180, 183, 187, 189, 193, 194, 195, 201, 203, and 206. Congener 99 was not used in the calculation of total PCBs because the reagent blank run with this batch had traces of a peak at the same time as PCB-99.

Another source of comparison data is the Environmental Protection Agency's National Human Monitoring Program, which measured general population exposure to various pesticides using samples collected in the Second National Health and Nutrition Examination Survey (NHANES II), 1976-1980. Data show that 99% of the U.S. population (women and men combined) had been exposed to p,p-DDE and that those exposed had an overall median level ranging from 11.8 ng/mL to 12.6 ng/mL (*31, 32*).

Although corresponding geographical animal data are sparse, we compared what was available to see if it reflected the chemical exposure patterns observed among the Alaska Native women. The animal data varied by location, but all of

Material may be protected by copyright law (Title 17, U.S. Code)

Table III displays these
that used these elevat-
ng levels in similar-aged
Missouri, Dorgan used
also reported lipid-cor-
n data came from 200
llected between 1977
ia Missouri Cancer Se-
in this population was
an total PCB level was
other 2 studies in Table
ers were used to calcu-
rgan study used the 28

general population
p,p-DDE and 2.0 ng/mL

Year of Sample	Study area
1980 - 1987	Alaska
1977 - 1987	Missouri
1964 - 71	California
1985 - 91	New York

they specify recovery
the PCB congeners 28, 52,
195, 201, 203, and 206.
batch had traces of a peak

ata is the Environmental
n Monitoring Program,
xposure to various pes-
Second National Health
HANES II), 1976-1980.
iation (women and men
DDE and that those ex-
ging from 11.8 ng/mL to

ohical animal data are
ble to see if it reflected
rved among the Alaska
ed by location, but all of

the samples contained detectable levels of the organochlorine chemicals found in our human samples. The six contaminants most frequently detected in Alaska Natives were also those most frequently detected in the marine mammal samples analyzed by Becker et al *(2, 5)* .The dominant PCB congeners in all of the marine mammal samples were congeners 153, 138, and 101. PCB congeners 153 and 138 were dominant in the Alaska Native population (Table II.).

Results for the Alaska Native women by geographical area are presented in Table IV. For the most part, organochlorine levels are higher in northwestern and southwestern areas than in south central or interior Alaska. Mean PCB levels in women from each of the four geographic areas of Alaska are higher than those reported in the Dorgan study of women in Missouri (*30*). Within the Alaska Native women study population, total PCB levels in women born in the northwestern (9.48 ng/mL) and southwestern (9.64 ng/mL) areas were about twice those of women born in south central (4.45 ng/mL) or interior Alaska (5.68 ng/mL). No such difference was noted for p,p-DDE.

Table IV. Mean level of organochlorine analytes among women in each geographic area, defined as where the participant lived at the time of cancer diagnosis or equivalent date for control subjects.

	Southcentral Mean (sd) (ng/mL) (n=47)	Northwestern Mean (sd) (ng/mL) (n=28)	Southwestern Mean (sd) (ng/mL) (n=50)	Interior Mean (sd) (ng/mL) (n=6)
Dieldrin	0.19 (0.24)	0.38 (0.41)	0.24 (0.28)	0.48 (0.14)
Hexachlorobenzene	1.35 (1.18)	4.08 (2.13)	3.03 (1.54)	1.44 (0.89)
Hexachlorocyclohexane	0.28 (0.40)	0.43 (0.54)	0.32 (0.42)	0.20 (0.43)
Oxychlordane	0.25 (0.42)	0.88 (0.80)	0.70 (0.74)	0.39 (0.23)
p,p-DDE	9.54 (4.04)	9.47 (5.99)	8.54 (4.68)	8.48 (4.07)
p,p-DDT	0.63 (0.88)	0.92 (1.10)	0.82 (0.97)	1.63 (0.80)
trans-Nonachlor	0.41 (0.60)	1.49 (1.29)	1.25 (1.12)	0.41 (0.23)
Total PCBs [a]	4.45 (4.12)	9.48 (5.82)	9.64 (6.38)	5.68 (1.83)

[a] Total PCBs were calculated as the sum of the PCB congeners 28, 52, 56, 66, 74, 101, 105, 110, 118, 138, 146, 153, 156, 170, 172, 177, 178, 180, 183, 187, 189, 193, 194, 195, 201, 203, and 206. Congener 99 was not used in the calculation of total PCBs because the reagent blank run with this batch had traces of a peak at the same time as PCB-99.

DISCUSSION

This paper reports levels of organochlorines in Alaska Native women. Our results are for women only and are derived from serum collected in the 1980s. The study demonstrates

Material may be protected by copyright law (Title 17, U.S. Code)

REFERENCES

1. Department of Health & Social Services, Alaska Division of Public Health, Section of Epidemiology. The use of traditional foods in a healthy diet in Alaska: Risks in perspective. State of Alaska Epidemiology Bulletin, Recommendations and Reports. Volume 2(1). Anchorage, 1998.
2. U.S. Department of Commerce, National Institute of Standards and Technology. Alaska Marine Mammal Tissue Archival Project: Sample inventory and results of analyses of selected samples for organic compounds and trace elements. NISTIR 4731. Washington DC: U.S. Department of Commerce, 1992.
3. Spencer WF, Cliath MM. Movement of pesticides from soil to the atmosphere. In: Long Range Transport of Pesticides. 1st edition (Kurtz DA, ed.). Chelsea MI: Lewis Publishers, 1990;1-16.
4. Dewailley E, Ayotte P, Suzanne B, Laliberte C, Muir DCG, Norstrom R. Inuit exposure to organochlorines through the aquatic food chain in Arctic Quebec. Poster presentation at the Ninth International Congress on Circumpolar Health, Iceland, June 1993. Environ Health Perspect 1993;6:8 620.
5. Becker PR, Koster BJ, Wise SA, Zeisler R. Biological specimen banking in Arctic research: an Alaska perspective. The Science of the Total Environment 1993;139/140:69-95.
6. Arctic Monitoring and Assessment Programme (AMAP). Arctic pollution issues: A state of the Arctic environment report. Oslo: 1997.
7. Ahlborg UG, Lipworth L, Titus-Ernstoff L, et al. Organochlorine Compounds in Relation to Breast Cancer, Endometrial Cancer, and Endometriosis: An Assessment of the Biological and Epidemiological Evidence. Crit Rev Tox 1995;25(6):463-531.
8. Stellman SD, Djordjevic MV, Muscat JE, Gong L, Bernstein D, Citron ML, White, Agnew, Kemeny M, Busch E, Nafziger AN. Relative abundance of organochlorine pesticides and polychlorinated biphenyls in adipose tissue and serum of women in Long Island, New York. Cancer Epidemiology Biomarkers & Prevention 1998;7:489-496.
9. US Geological Survey. Pesticides in the Atmosphere, USGS Fact Sheet FS-152-95. Sacramento CA, 1995.
10. Kinloch D, Kuhnlein H, Muir DCG. Inuit foods and diet: a preliminary assessment of benefits and risks. The Science of the Total Environment 1992;122:247-278.
11. Wania F, Mackay D. Global fractionation and cole condensation of low volatility organochlorine compounds in polar regions. Ambio 1993;22(1):10-18.

that there is widespread exposure to many different organochlorines among Alaska Native women, and our results provide a reference baseline for future investigations of organochlorine exposure in these women. It is also of note that organochlorine exposure in women is probably a conservative estimate of total population exposure because organochlorine levels in men may be higher than in women, who decrease body burden through lactation (*7*).

Although the women in this project were not selected to be a representative sample, their ethnic and geographic distribution is consistent with Alaska census reports in which the majority of Alaska Natives are ethnically identified as Eskimo and geographically located in the northern, northwestern, and southwestern areas of Alaska (*33*). Sixty-two percent of our study population were Eskimos, and most lived in one of these three geographic areas. Our results confirm that Alaska Natives are exposed to organochlorines that almost certainly are not used locally, but instead have been atmospherically transported to the region (*3*). Although animal data in Alaska are sparse, the existing data point to subsistence food consumption as the plausible route of exposure (*2, 5*). This assumption is strengthened by our finding that Alaska Native serum PCB congener profiles are similar to those found in tissues of marine mammals that make up part of the subsistence diet of Arctic populations (*2, 34*). Five of the organochlorine compounds (i.e., p,p DDE, hexachlorobenzene, trans-nonachlor, oxychlordane, dieldrin) were detected in more than half of our study population. Such pervasive exposure of Alaska Native women to man-made chemicals with potential health implications is difficult to interpret when compared to other populations. We used several approaches to conservatively compare our results to studies conducted in other parts of the United States. However, our comparisons only addressed DDE and total PCBs because they are the analytes frequently and consistently reported in the literature. Although some researchers have reported mean or median levels for other organochlorines, these estimates are usually derived from samples where less than 50% of the study population is above the level of detection; the findings are therefore unstable.

In comparing our findings of Alaska Native with those from NHANES II, which used similar laboratory methods but included both women and men, we found both similarities and differences in the percentage of the study populations with detectable levels of a particular analyte. More than 99% of the samples from Alaska Native women in our study and

Material may be protected by copyright law (Title 17, U.S. Code)

NHANES II subjects had detectable levels of p,p-DDE (*31*, *32*). In contrast, 98.5% of our Alaska Native women had detectable levels of hexachlorobenzene, whereas less than 5% of NHANES II subjects did. Similarly, we found that 70.2% of our sample had detectable levels of trans-nonachlor versus 7.1% in NHANES II (data not shown). One explanation for these differences may be the route of exposure experienced by Alaska Natives as compared to other Americans during the 1970s and 1980s. Whereas people living in the lower 48 states of the US may have been exposed to organochlorines in the workplace, during mosquito control campaigns, or as a residue on annually specific agricultural products, Alaska Natives have been and continue to be exposed to these chemicals almost exclusively through consumption of a subsistence diet that efficiently biomagnifies these chemicals. Alaska Natives appear to be unique because their organochlorine exposure is elevated across a geographically and ethnically diverse population and includes many of the organochlorine chemicals.

The mean total PCB level in Alaska Native women in our study (Table III) was higher than those reported for women by Dorgan, Krieger, or Wolff (*28-30*); however the standard deviation was higher and the sample size smaller in our study. The findings are therefore of interest but should not be overinterpreted. The variability in total PCBs by geographical area is of greater interest and may be related to differences in PCB levels between marine mammals consumed in the coastal areas (northwestern and southwestern Alaska) and river fish and game animals consumed as part of the inland subsistence diet. However this clearly requires further investigation to eliminate point source exposures. Repetition of this study with a larger sample size will provide insight into potential differences in PCB levels among Alaska Natives who live in coastal Alaska as compared to those living inland.

Comparisons of our study results to other published studies of organochlorine exposure among women are limited by undefined laboratory parameters that may potentially restrict comparability of reported values. Although analytical laboratories may follow similar protocols, their results may still not be comparable. Each may use slightly different methods for lipid adjustment or recovery correction, varying procedures for quality control, subjective criteria for interpreting interference peaks, or even different reporting criteria. Lipid adjustment is simply an analytical method that compensates for an individual's fasting or non-fasting status, which enhances comparability. However, not all researchers report lipid-ad-

12. Jensen S, Jannson B, Olsson M. Number and identity of anthropogenic substances known to be present in Baltic seals and their possible effects on reproduction. Ann NY Acad Sci 1979;320:436-448.
13. Muir DCG, Wagemann R, Grift NP, Norstrom RJ, Simon M, Lien J. Organochlorine chemical and heavy metal contaminants in white-beaked dolphins (*Lagenorhynchus albirostris*) and pilot whales (*Globicephala melaena*) from the coast of Newfoundland, Canada. Arch Environ Toxicol Chem 1988;17:613-629.
14. Addison RF, Brodie PF, Zinck ME, Sergeant DE. Residues of organochlorine pesticides and polychlorinated biphenyls in some commercially produced Canadian marine oils. J Fish Res Board Can 1972;29:349-355.
15. Gaskin DE, Frank R, Holdrinet M. Polychlorinated biphenyls in harbour porpoises, *Phocoena phocoena (L)*, from the Bay of Fundy, Canada and adjacent waters, with some information on chlordane and hexachlorobenzene levels. Arch Environ Contam Toxicol 1983;12:211-219.
16. Masse R, Martineau D, Tremblay L, Beland P. Concentrations and chromatographic profile of DDT metabolites and PCB residues in stranded beluga whales (*Delphinapterus leucas*) from the St Lawrence estuary - Canada. Arch Environ Contam Toxicol 1986;15: 567 - 579.
17. Sassenbrecker PW. Levels of DDT and PCB compounds in North Atlantic fin-back whales. Can J. Comp Med 1973;37: 203-206.
18. Taruski AG, Olney CE, Winn HE. Chlorinated hydrocarbons in cetaceans. J Fish Res Board Can 1975;32:2205-2209.
19. Nobman E. Assessment of current dietary intakes of Alaska Native adults. Alaska Area Native Health Service; Project 88-07, 1989.
20. Dewailley E, Ryan JJ, Laliberte C, Bruneau S, Weber JP, Gingras S, Carrier G. Exposure of remote maritime populations to co-planar PCBs. Env Health Persp Suppl 1994;102(1):205-209.
21. Kuhnlein H, Receveur O, Muir DCG, Chan H, Soueida R. Arctic indigenous women consume greater than acceptable levels of organochlorines. J Nutr 1995a;125:2501-2510.
22. Kuhnlein H. Benefits and risks of traditional food for indigenous peoples: focus on dietary intakes of Arctic men. Can J Physiol Pharmacol 1995b;73:765-771.
23. Wormworth J. Toxins and tradition: the impact of food chain contamination on the Inuit of Northern Quebec. Can Med Assoc J 1995;152(8):1237-1240.
24. Norstrom RJ, Simon M, Muir DCG, Schweinsburg RE. Organochlorine contami-

Material may be protected by copyright law (Title 17, U.S. Code)

nants in Arctic marine food chains: identification, geographical distribution, and temporal trends in polar bears. Environ Sci Technol 1988;22:1063-1071.
25. Rubin CH, Lanier A, Brock JB, Harpster A, Hoar Zahm S, Kieszak S, Blair A, Sinks T. Breast cancer risk among Alaska Native women exposed to environmental organochlorine chemicals. In press.
26. Brock J, Burse V, Ashley D, Najam A, Green V, Korver M, Powell M, Hodge C, Needham L. An improved analysis for chlorinated pesticides and polychlorinated biphenyls (PCBs) in human and bovine sera using solid-phase extraction. J Analy Tox November/December; 1996;20:528-536.
27. Phillips DL, Pirkle JL, Burse VW, Bernert JT Jr; and others. Chlorinated hydrocarbon levels in human serum: effects of fasting and feeding. Arch Environ Contam Toxicol 1989;18(4):495-500.
28. Krieger N, Wolff MS, Hiatt RA, Rivera M, Vogelman J, Orentreich N. Breast Cancer and Serum Organochlorines: a Prospective Study Among White, Black, and Asian Women. J Natl Cancer Inst 1994;86:589-599.
29. Wolff MS, Toniolo PG, Lee EW, Rivera M, Dubin N. Blood Levels of Organochlorine Residues and Risk of Breast Cancer. J Natl Cancer Inst 1993;85:648-652.
30. Dorgan JF, Brock JW, Rothman N, Needham LL, Miller R, Stephenson HE Jr, Schussler N, Taylor PR. Serum organochlorine pesticides and PCBs and breast cancer risk: results from a prospective analysis (USA). Cancer Causes Control 1999;10(1):1-11.
31. Murphy R, Harvey C. Residues and metabolites of selected persistent halogenated hydrocarbons in blood specimens from a general population survey. Environ Health Perspect 1985;60:115-120.
32. Stehr-Green PA. Demographic and seasonal influences on human serum pesticide residue levels. Journal of Toxicology and Environmental Health 1989;27:405-421.
33. Alaska Area Native Health Service; Division of Planning, Evaluation & Health Statistics. *Alaska Area Program Information Summary*. Anchorage, Alaska; 1991.
34. Schantz MM, Koster BJ, Wise SA, Becker PR. Determination of PCBs and chlorinated hydrocarbons in marine mammal tissues. Sci Total Environ 1993;139/140:323-345.

justed results (*28, 29*) or whether lipid adjustment alters their crude results. Whereas some studies have reported that lipid-adjusted results reflect more precise estimates than do crude results (*8*), we found that lipid adjustment did not significantly alter the findings in our case-control study (*25*).

Another potential problem concerns the recovery value inherent to every individual laboratory extraction method. Crude organochlorine values are those readings reported by the instrument. Each laboratory must also analyze spiked samples of known strength to determine the percentage that is recovered during a specified procedure. Recovery-corrected values are obtained by taking the unadjusted value and dividing by the proportion recovered (*26*). In a case-control study, it is valid to compare crude (i.e., not recovery corrected) values, but these values may not provide a valid basis for comparison to results from other studies. Many of the publications regarding human levels of organochlorines are based upon case-control statistical analyses and do not mention whether their data have been recovery corrected. Because recovery correction may increase values by 30%, the correction status of the results must be defined and accounted for when data are compared with results from other studies.

Results from different studies may also vary because of such basic technical realities as limit of detection constraints. For example, methods currently used in the CDC laboratory have a 95% detection limit for p,p-DDE of 0.41 ng/mL, and detection limits for PCB congeners that range from 0.11 - 0.30 ng/mL. In the same laboratory, methods from less than 5 years ago had detection limits of 1.0 ng/mL for p,p-DDE and 2.0 ng/mL for total PCBs. Differences in detection limits will determine how many subjects are included in mean value calculations and the percentage reported as having detectable levels of the substance for which we are testing.

CONCLUSION

The organochlorine levels we found in serum from 131 Alaska Native women provide a reference baseline for exposure manifested in the 1980s. Organochlorine levels in Alaska Native women were similar to those of women elsewhere in the U.S., although the route of exposure to many organochlorine compounds appears to be different in Alaska than other geographical areas in the U.S. Because of differences in laboratory methods and reporting practices, all comparisons between our study population and others reported in the liter-

Material may be protected by copyright law (Title 17, U.S. Code)

ature must be made cautiously.

This study reflects one point in time; no trend data are presently available for the Alaska Native populations. We have used the results of this study to develop a project that will define changes in organochlorine exposure levels over time, using individual dietary information to more fully characterize exposure patterns and provide insight into the interpretation of organochlorine levels among Alaska Native women.

Carol H. Rubin, DVM, MPH

Chief, Health Studies Branch

1600 Clifton Road, NE MS-E23 Atlanta, GA 30333

Building 6, Room 1012 Executive Park Drive

Atlanta, GA 30329

phone: 404-639-2571

fax: 404-639-2565

e-mail: chr1@cdc.gov

Material may be protected by copyright law (Title 17, U.S. Code)